An Automatic Finite-Sample Robustness Metric: Can Dropping a Little Data Make a Big Difference?

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Job talk 2021

Dropping data: Motivation

Suppose you're a data analyst, and you've

- Gathered some exchangeable data,
- Cleaned up / removed outliers,
- Checked for correct specification, and
- Drawn a conclusion from your statistical analysis (e.g., based the sign / significance of some estimated parameter).

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Would you be concerned if you could **reverse your conclusion** by removing a **small proportion** (say, 0.1%) of your data?

Dropping data: Mexico Microcredit

Consider Angelucci et al. [2015], a randomized controlled trial study of the efficacy of microcredit in Mexico based on 16,560 data points. The variable "Beta" estimates the effect of microcredit in US dollars.

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Question: Is the reported interval $-4.55 \pm (5.88)$ a reasonable description of the uncertainty in the estimated efficacy of microcredit?

Can Dropping a Little Data Make a Big Difference?

Do you care whether you can **reverse your conclusion** by removing a **small proportion** of your data?

Not always!

...but sometimes, surely yes.

For example, it often occurs that:

- Policy population is different from analyzed population,
- Small fractions of data are missing not-at-random,
- We report a convenient summary (e.g. mean) of a complex effect,
- Models are stylized proxies of reality.

How do we find influential datapoints?

The number of subsets $\binom{N}{\lfloor \alpha N \rfloor}$ can be very large even when α is small.

In the MX microcredit study, $\binom{16560}{15} \approx 1.4 \cdot 10^{51}$ for $\alpha = 0.0009$.

We provide a fast, automatic approximation based on the **empirical influence function**.

Though we provide finite-sample, non-stochastic accuracy guarantees, there is no need to rely on our theory. A single re-fit provides an exact lower bound on sensitivity.

Can Dropping a Little Data Make a Big Difference?

What causes sensitivity to dropping small fractions of the data?

We examine a number of published analyses:

- Seven studies of microcredit [Meager, 2020]
- The Oregon Medicaid experiment [Finkelstein et al., 2012]
- A study of cash transfers [Angelucci and De Giorgi, 2009]

Some analyses were robust, and others were not.

What drives the variety of results?
We show that sensitivity to dropping small subsets is:

- Not (necessarily) caused by misspecification.
- Not (necessarily) caused by outliers.
- Not captured by standard errors.
- Not mitigated by large N.
- Primarily determined by the **signal to noise** ratio

  ... that is, the ratio of the measured effect size to data variability.

Links and references

Tamara Broderick, Ryan Giordano, Rachael Meager (alphabetical authors)
"An Automatic Finite-Sample Robustness Metric: Can Dropping a Little Data Change Conclusions?"
https://arxiv.org/abs/2011.14999

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